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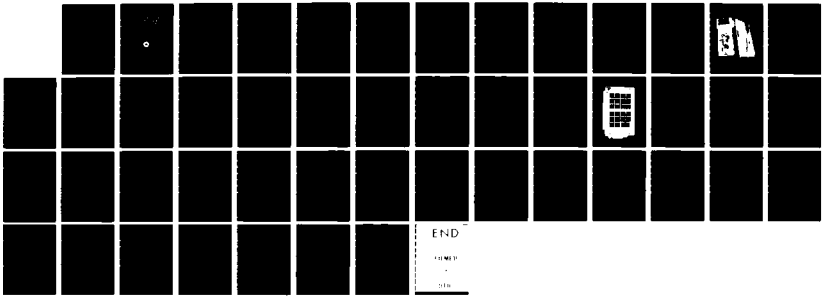

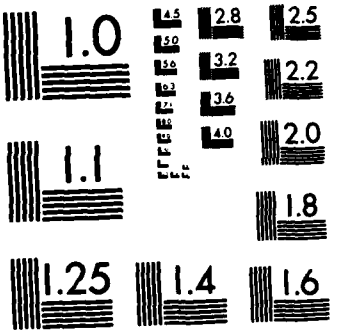

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# PILOT
# A PRECISION INTERCOASTAL LORAN TRANSLOCATOR
## VOLUME I—USERS MANUAL


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March 1982

Final Report

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16. Abstract

PILOT is an electronic aid for navigation in piloting waters. It consists of an OEM microprogrammable graphics terminal configured to receive Loran and ship's gyro inputs. Software in the terminal computes a fix and outputs vessel position in both digital and graphic representation. A number of display modes are available to the operator through a customized 23 key keypad in addition to augmentations such as range and bearing to a point or projection of vessel's future position.

Procedures are given for installing PILOT aboard a ship and interfacing it to a Loran receiver. Operating instructions are detailed for all of its navigation and piloting functions. Additionally, a product description of the Internav LC404 Loran receiver is included since this is the unit presently used for PILOT.

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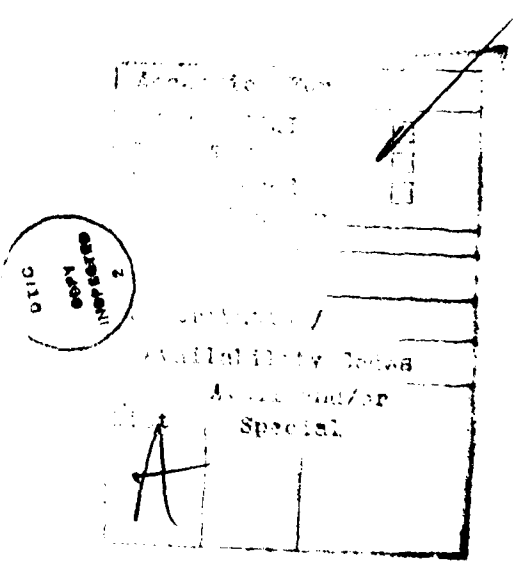
## ABSTRACT

PILOT is an electronic aid to piloting vessels in rivers and harbors. Procedures are described for installing and operating the equipment specially built for the PILOT system by the Applied Physics Laboratory. A product description of the Internav LC 404 loran receiver used with the PILOT terminal is also included.



CONTENTS

## ILLUSTRATIONS



## TABLES

## FOREWORD

The present PILOT terminal is the product of a long evolution of special purpose loran processors developed at the Applied Physics Laboratory. In 1968 a Loran Assist Device (LAD) was developed for a unique military aircraft requirement and was followed by several other military versions. In 1970 a Coast Guard Loran Assist Device (COGLAD) was developed to evaluate loran as an aid to positioning buoys. With the development of microprocessors in 1973, a small, simple processor (CLAD) was developed and tested by the Coast Guard. The original COGLAD was upgraded and tested on the St. Marys River in 1976. Each new system utilized increasingly sophisticated data processing techniques, required less operator training and attention, and represented a lower potential production cost. These improvements were largely the result of the phenomenal developments in the integrated circuit and microprocessor industry in the last decade.

The design objective of the PILOT system was to demonstrate that loran repeatability (i.e., returning to presurveyed way points) could be successfully used to pilot harbors and rivers without significantly increasing the workload of the bridge personnel, and that the system could be mass produced by industry for an affordable price. To minimize development and production costs, a commercially available (Hewlett-Packard 2649A) microprogrammable graphics terminal was selected as the nucleus of the PILOT system. Significant hardware modifications were required, but most are of the plug-in or bolt-on type and do not change the basic H-P terminal. The loran receiver currently used with the system is an unmodified commercial item. Extensive new software was developed for this application and included sophisticated data filtering and transformation techniques.

Documentation for the PILOT system is contained in three volumes: Volume SDO 5699 Users Manual, Volume SDO 5699.1 Hardware, and Volume SDO 5699.2 Software. Additional documentation is contained in Hewlett-Packard 02648-90002 Reference Manual, H-P 13255-9100 Technical Information Package, and H-P 13255-90010 Operating System Microcode. For installation and operation the user only needs to be familiar with the Users Manual.

## ABBREVIATIONS

(appearing on PILOT display and used throughout this manual)

| | |
|---|---|
| ATD | Along-Track Distance |
| CTD | Crosstrack Distance |
| ATS | Along-Track Speed |
| CTS | Crosstrack Speed |
| TTG | Time To Go |

(used throughout this manual)

| | |
|---|---|
| AMD | Advanced Micro Devices |
| CMG | Course Made Good |
| CRT | Cathode Ray Tube |
| CTD BAR | Crosstrack Distance Bar Graph |
| GRI | Group Repetition Interval |
| H-P | Hewlett Packard |
| MST/DET | Master/Detail |
| OEM | Original Equipment Manufacturer |
| PROJ | Project |
| RNG&BEAR | Range and Bearing |
| S/D | Synchro/Digital |
| STAT | Status |
| TD | Time Difference |
| WP | Way Point |

# 1.0 INTRODUCTION

## 1.1 GENERAL

The PILOT terminal, developed by the Applied Physics Laboratory of the Johns Hopkins University for the U.S. Coast Guard, is an electronic aid to piloting vessels in harbors and rivers. Its purpose is to provide accurate navigation information in a format that can be immediately used without significantly increasing the bridge workload. It is not intended to make value judgements or steer the ship, but it does provide the ship with continuous and accurate position information over-the-bottom. The PILOT terminal obtains its information from a Loran-C receiver, the ship's gyro, and charts and loran coefficients prerecorded on magnetic tape cartridges. These data are edited for accuracy, filtered for smoothness, and mathematically transformed into various display formats. The data are presented graphically with respect to a local way point (WP), and as a horizontal bar graph to aid channel keeping. The startup procedure for the PILOT system consists basically of selecting the appropriate tape cartridge and, after the receiver has automatically acquired the loran signals, commanding the PILOT terminal to start navigation. Once started, the PILOT system will continuously compute position and velocity information, and select new area charts as necessary without further operator action. The operator may enable optional features and display enhancements if desired.

Prerecorded tape cartridges containing a sequence of charts and other navigation information provide the PILOT terminal with a degree of "local knowledge". The vessel's present position, speed, and heading, continuously determined from a loran receiver and the vessel's gyro, are displayed on the current area chart. Charts of two different scales (master and detail) are always available for operator selection. Position, speed, and time to go (TTG) relative to way points are displayed to the left of the chart. A horizontal bar graph, representing the vessel's crosstrack position relative to the track line, can be displayed along the bottom of the display.

Other features available to the operator include a capability for projecting the vessel's expected track line, continuous readout of range and bearing from ownship to any point on the displayed chart, a time-of-day clock, and zoom in, zoom out, and pan on the displayed chart. The operator can enter time difference (TD) bias values to compensate

for seasonal variation, select from three types of vessel projections, select from four data filter time constants, and display ship's gyro and loran receiver data. Using a special diagnostic tape cartridge the operator can perform self tests on the PILOT terminal. When used with a line printer the PILOT terminal can print position information at a fixed time interval, or be used as a survey system to measure the mean and standard deviation of the TD's of the vessel's present position.

## 1.2 HARBOR CHART TAPE CARTRIDGES

All coordinate conversion constants and navigational reference information, as well as a mosaic of harbor charts, are contained on a cartridge which is, in effect, a Loran-C harbor chart on a magnetic medium. A single cartridge contains as many as 200 of these charts, representing about 200 miles of river or harbor.

Each cartridge contains an index file, master files and detail files. The index file contains a title block and a list of all master charts on the cartridge. The index file is always displayed before the PILOT terminal begins the navigation mode and any time the terminal is reset.

Each master file contains the graphics for a master chart showing 8-16 miles of track (a scale of about 1:50000), the area transformation coefficients, transmitter coordinates, and supplemental data such as display origin, scale, and rotation. Master charts provide "look ahead" by showing the next several way points and the identity of a few prominent features. Because master charts are generally not large enough for piloting in narrow channels, each master chart has one or more detail charts associated with it.

Each detail file contains the graphics for a detail chart showing 1-2 miles of track (a scale of about 1:12500), the TD's, and X,Y coordinates of the current way point, bearing angles to and from the WP, and supplemental data. Detail charts provide a closer view of the vessel's current situation, and include many of the fixed aids to navigation and the outline of the channel if applicable.

The process for producing chart cartridges was developed at APL, where the original cartridges for the St. Marys River were produced. The Coast Guard R&D Center, Groton, CN has now taken over the production of cartridges.

Beginning with the appropriate NOAA (National Ocean and Atmospheric Administration) charts, the process for producing cartridges includes: 1) Selecting appropriate chart areas and way points for the river or harbor; 2) digitizing NOAA charts and adjusting to the proper scale, rotation, and origin (this step determines whether the chart displayed on the PILOT terminal will be north-up or track-up); 3) computing transformation coefficients for the geometry of the Loran-C chain to be used; 4) conducting a loran survey of the river or harbor; 5) combining the above data into the proper format and recording it onto magnetic cartridges. The Coast Guard R&D Branch, Washington, DC has developed new techniques for surveying the loran coordinates of each way point. Using the actual measured TD's, rather than theoretical TD's, greatly enhances the accuracy of the PILOT system.

## 1.3 HARDWARE CONFIGURATION

The PILOT terminal is shown in Fig. 1, and the system block diagram is shown in Fig. 2. Normal shipboard installation consists of the PILOT terminal, a loran receiver (currently the Internav 404 receiver) and a cable connection to the ship's gyro. Optional equipment includes a second loran receiver (for cross chain operation), an interface or modem for remotely entering TD bias values, and a printer.

The nucleus of the PILOT system is a Hewlett Packard 2649A microprogrammable graphics terminal. This OEM device was selected because it has a separate graphics processor with memory, dual tape cartridge units, and an Intel 8080 microprocessor that could be modified and programmed as required. Modifications to the H-P 2649A included: converting the 8080 microprocessor from software arithmetic to hardware arithmetic by adding an Advanced Micro Devices (AMD) 9511 arithmetic processing unit, developing an interface board to preprocess loran data from two loran receivers, developing an interface board to connect to the ship's gyro, and a TD bias modem or box, replacing the large general purpose keyboard with a small predefined keypad, and building a short base for the terminal to serve as a cable junction box.

## 1.4 SOFTWARE CONFIGURATION

Figure 3 is the PILOT terminal functional data flow diagram. Approximately 17,000 bytes of machine language code was developed at APL for the PILOT terminal and an additional 40,000 bytes of the original H-P code was retained. Structured programming and assembly language were used for maximum efficiency.

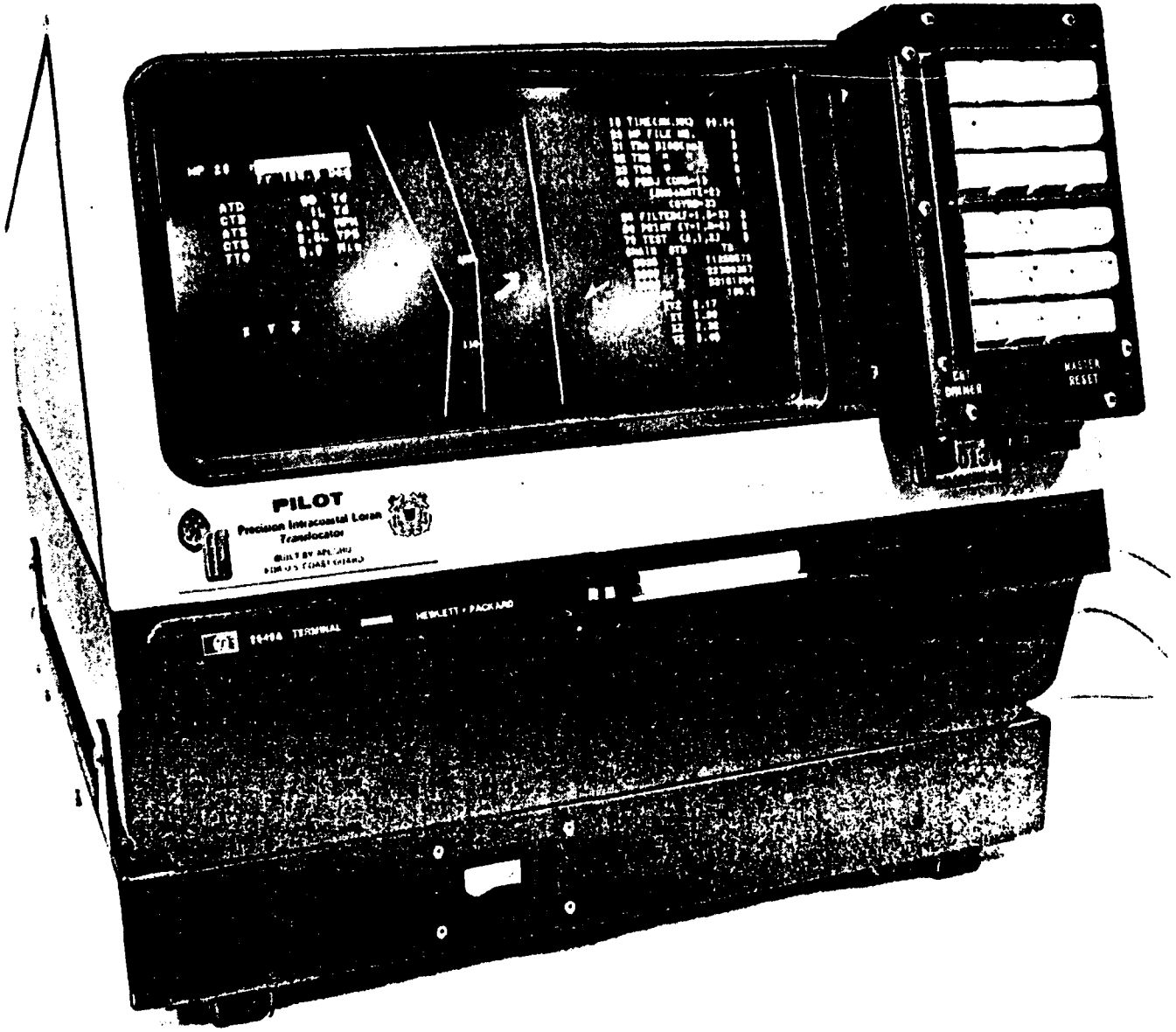



**Fig. 1 PILOT terminal.**

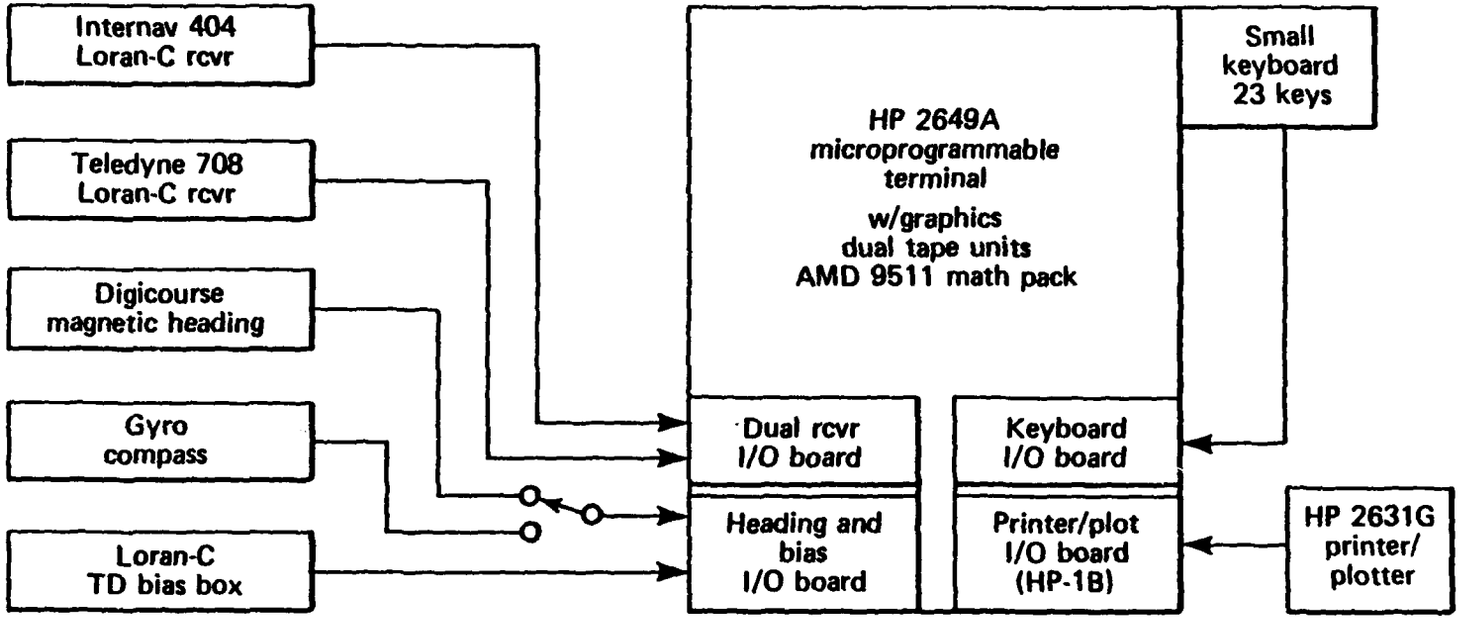



**Fig. 2 System block diagram.**

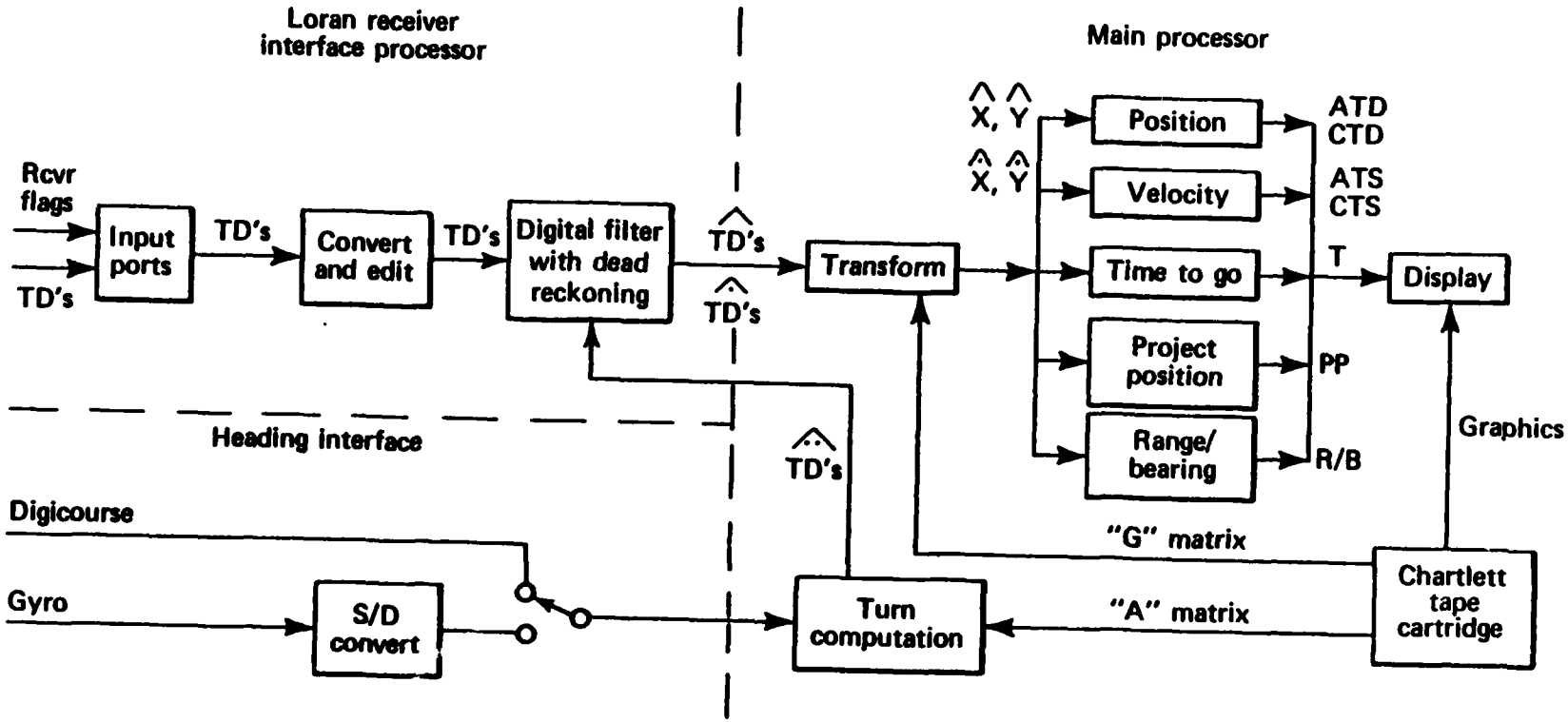



Fig. 3 Functional data flow diagram.

# 2.0 INSTALLATION

## 2.1 GENERAL

Normal shipboard installation consists of the PILOT terminal, a loran receiver and a cable connection to the ship's gyro compass. For maximum effectiveness, the PILOT terminal should be mounted on the forward bulkhead of the wheelhouse, facing aft and close to the pilot's normal position. Direct sunlight on the display screen should be avoided, otherwise a sunshade may be necessary.

Caution! Mounting the PILOT terminal less than three feet from the ship's magnetic compass or compensation magnets may cause compass deviation and distortion of the PILOT display.

Mounting the loran receiver adjacent to the PILOT terminal is a convenience but is not essential; however, the maximum length for the receiver to terminal interface cable is 60 feet. Location of the loran antenna is generally not critical, but it should not be mounted near transmitting antennas or radar antennas. The 75 feet of antenna cable normally supplied with the receiver can be extended to a maximum of 200 feet.

To open the PILOT terminal: 1) turn power OFF and disconnect power cord, 2) from front of terminal, insert access key (or end of paper clip) into right keyway and unlock right side by slightly raising right side of top cover, 3) while maintaining upward pressure on right side, insert access key into left keyway and unlock left side; 4) using both hands, carefully swing top cover up until it latches into the half-open position.

## 2.2 SPECIFICATION

Table 1 lists the power requirements, environmental limits and physical specifications of the PILOT terminal.

## 2.3 MECHANICAL CONFIGURATION

Figure 4 shows the overall dimensions and mounting hole dimensions for the PILOT terminal.

Table 1

PILOT Specifications

POWER REQUIREMENTS

Input Voltage: 115 V (+10%, -23%) at 60 Hz (+/- 0.2%)
230 V (+10%, -23%) at 60 Hz (+/- 0.2%)

Power Consumption: 150 watts

ENVIRONMENTAL CONSIDERATIONS:

Temperature, Free Space Ambient:
Non-Operating: -10 to 60 deg C (-15 to 140 deg F)
Operating: 5 to 40 deg C (+41 to 104 deg F)

Humidity: 5 to 95% (non-condensing)
Humidity: (with tapes): 20 to 80% (non-condensing)

Vibration and Shock:
Vibration: 0.25 mm (0.010") pp, 10 to 55 Hz, 3 axis
Shock: 30 g, 11 ms, 1/2 sine

Physical Specifications:
PILOT Terminal Weight: 26 kg (57 lb)
PILOT Terminal Dimensions: 444 mm W × 489 mm D × 414 mm H
(17.7" W × 19.5" D × 16.5" H)

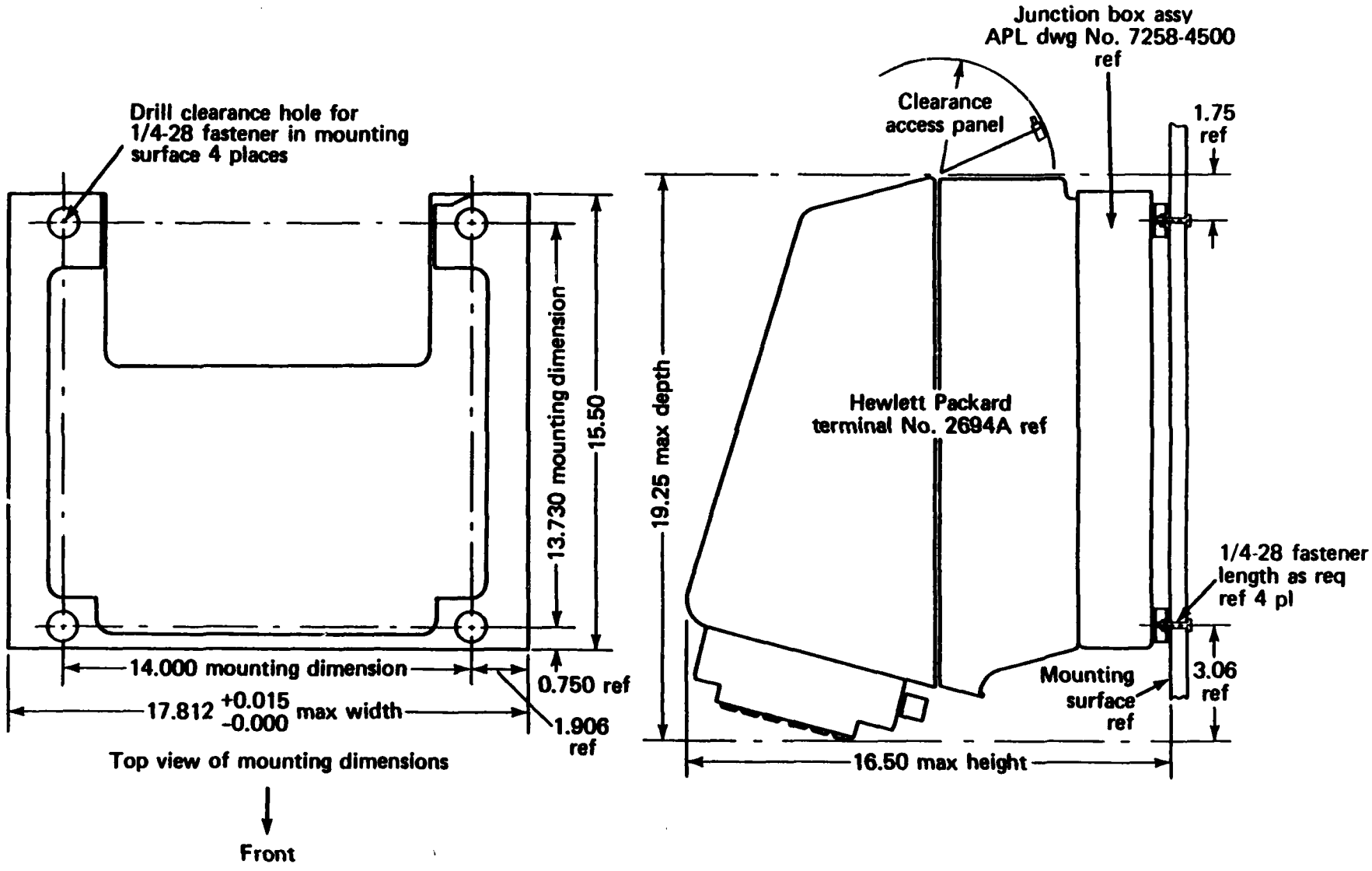



**Fig. 4 Mechanical configuration of PILOT terminal.**

## 2.4 ELECTRICAL CONFIGURATION

Figure 5 shows the interconnect cabling for the PILOT system.

Note: A 250 VA constant voltage transformer is normally supplied with each PILOT system and is recommended for most ship installations.

## 2.5 LORAN RECEIVER

Consult the receiver users manual for specific installation instructions. (In lieu of a users manual, the appendix contains the product description for the Internav LC 404 receiver.)

## 2.6 GYRO COMPASS CONNECTION

The PILOT terminal gyro interface is designed for a 3 phase, 60 Hz, 90 volt gyro, and has a minimum input impedance of 200 Kohms. For ships having a 3 contact, 70 VDC stepper gyro, such as the Mark 14, Mod 1, an adaptor box is available. Refer to Fig. 6 for pin function assignments.

## 2.7 VESSEL DIMENSION SWITCHES

The length and beam of the vessel, and the antenna distance from the bow should be set in special switches inside the PILOT terminal so that the scale and location of the vessel symbol will be correct. These switches are located on the TD BIAS & HEADING BOARD and are labeled LENGTH, BEAM, and ANTENNA. Each of the eight ON/OFF toggles on the switches represents a different length. The total length represented by a switch is the sum of all toggles in the ON position. The value for each toggle is as follows:

| Toggle No. | Length & Antenna | Beam |
|---|---|---|
| 1 | 512 ft | 128 ft |
| 2 | 256 | 64 |
| 3 | 128 | 32 |
| 4 | 64 | 16 |
| 5 | 32 | 8 |
| 6 | 16 | 4 |
| 7 | 8 | 2 |
| 8 | 4 | 1 |

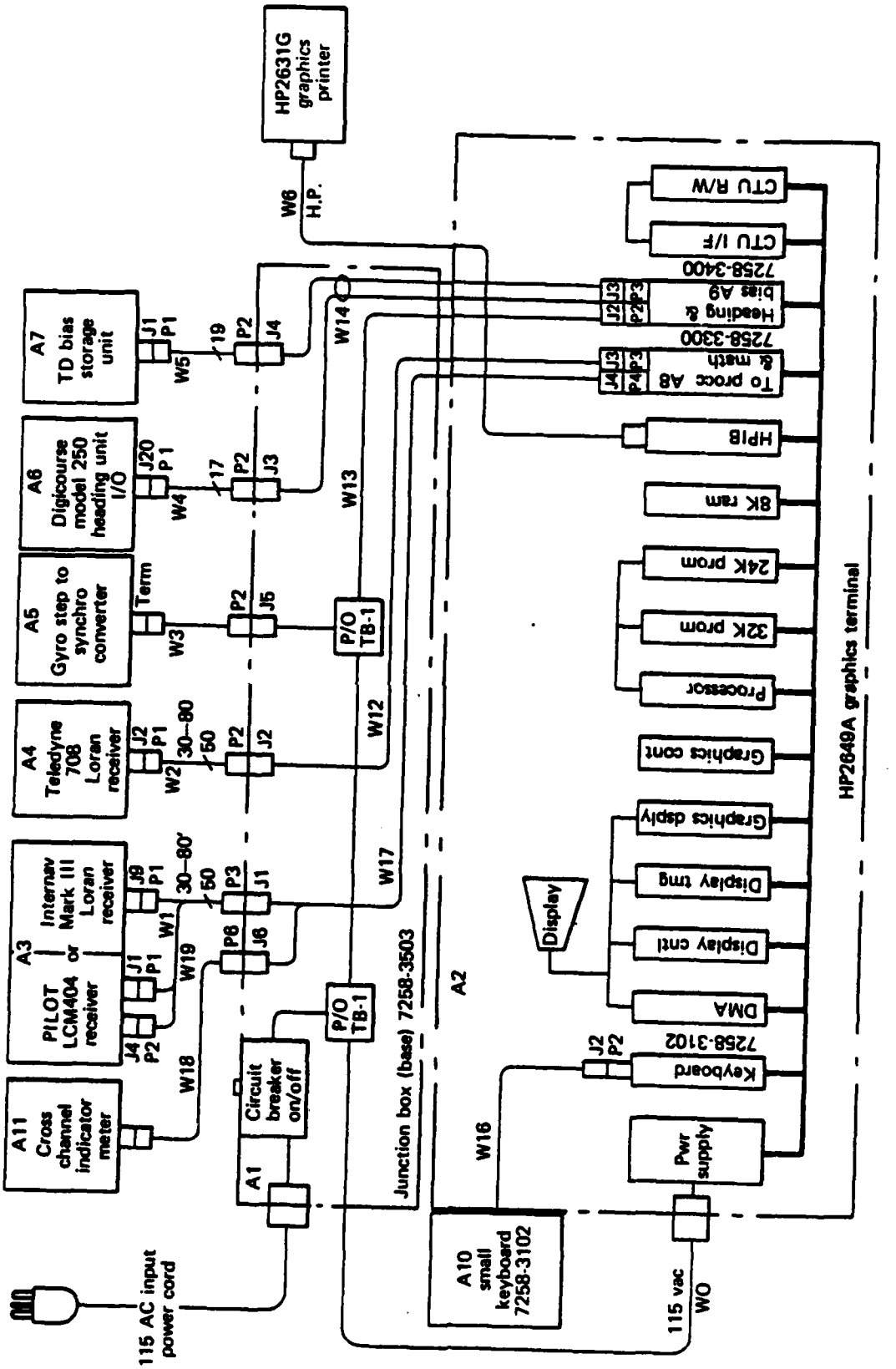



Fig. 5 Interconnect cabling diagram.

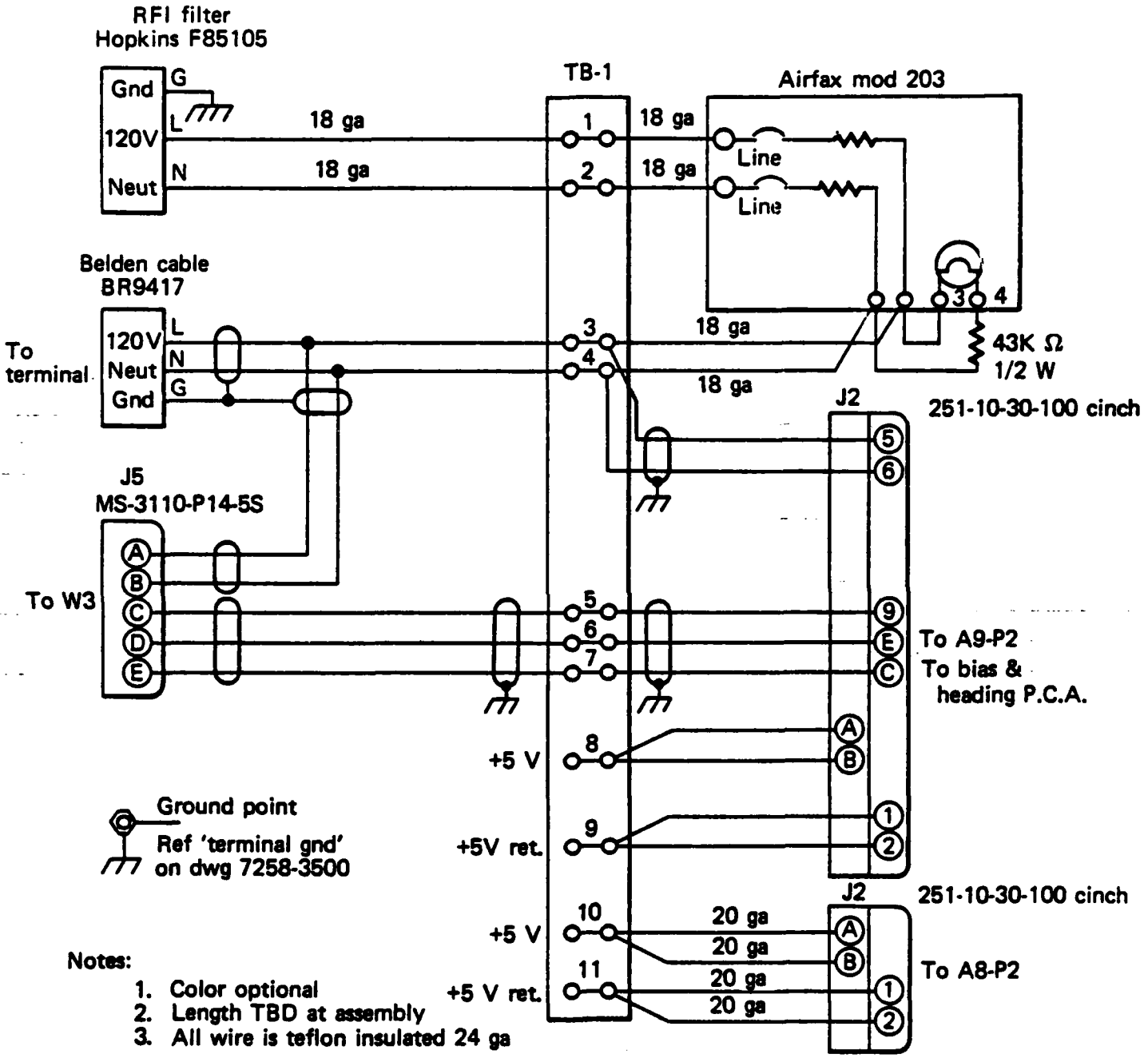



**Fig. 6 Pin function assignments for gyro compass connection.**

Examples:

If length is 140 ft.
on the LENGTH switch, set toggles 3 (=128'), 7 (=8') and 8 (=4') to the ON position, thus 128 + 8 + 4 = 140 ft.

If beam is 28 ft.
on the BEAM switch, set toggles 4 (=16'), 5 (=8') and 6 (=4') to the ON position.

If antenna is mounted 49 ft aft of bow
on the ANTENNA switch, set toggles 3 (=32') and 4 (=16')

Note: 49' cannot be entered, only multiples of 4 feet.

## 2.8 DIAGNOSTIC TEST

The PILOT terminal can be tested using a "PILOT Diagnostic" tape. This test will check out the PILOT terminal and the gyro interface but not the receiver or the receiver interface. Turn the terminal ON, insert the diagnostic tape into the LEFT top slot and press the MASTER RESET button twice within 0.5 seconds. After the display has settled, observe the instructions and expected results for each of the two test conditions. Select one test by pressing STAT, 70, 1 or 2, and EXECUTE. Observe that the correct answers are displayed.

To test the complete PILOT system, including the receiver, proceed to Section 4.0 OPERATING PROCEDURE.

# 3.0 KEYBOARD

## 3.1 GENERAL

The APL developed keyboard consists of 23 keys, a MASTER RESET switch, and a CRT DIMMER control. The bottom 11 keys (see Fig. 7) are special purpose command keys, and the top 12 keys are general purpose numerical and cursor control keys. Table 2 lists the normal command sequences (see Section 4.0 OPERATING PROCEDURE for a more detailed description of the operation of these commands). The upper left area of the display is reserved for the command display buffer. When a command key is pressed, the command function is echoed in the command buffer display. If the command sequence also requires a numerical input a field of inverted video follows the command name as a prompter. All commands, except ZOOM IN and ZOOM OUT, must be terminated with the EXECUTE key.

The keys are automatically and selectively enabled and disabled by the PILOT software to minimize operator errors. The normally disabled numerical keys are enabled only when a numerical input is required. Pressing a command key causes all other command keys (except CLEAR and EXECUTE) to be disabled until the command is completed or aborted. The numerical keys 2, 4, 6, and 8 are automatically shifted to cursor control keys when the RNG&BEAR and PAN keys are pressed. Pressing a disabled key causes an audible "beep" but is otherwise ignored.

## 3.2 STATUS COMMAND

The STAT (Status) key has an additional level of command to allow the operator to monitor and control secondary functions. Pressing STAT, EXECUTE causes the status format to be displayed on the right side of the screen, see Fig. 8. All numbered lines contain data that can be changed by the operator. Press STAT, (line number), (data) and EXECUTE to enter new data. This additional level of command is only activated when the status display is on the screen. Pressing CLEAR, STAT and EXECUTE removes the status display from the screen but does not modify any status data.

Table 2

PILOT Command Sequences

| | |
|---|---|
| PROJ., MM.M, EXECUTE | Displays project mode and enters project time where MM.M is time in minutes |
| CLEAR, PROJ., EXECUTE | Turns project OFF, does not change project mode |
| RNG&BEAR, < > ∧ ∨, EXECUTE | Selects new reference point for range and bearing |
| CLEAR, RNG&BEAR, EXECUTE | Turns range and bearing OFF |
| MST/DET, EXECUTE | Switches display to alternate (master or detail) graphics chart |
| CTD BAR, EXECUTE | Displays cross track distance bargraph across bottom of display |
| CLEAR, CTD BAR, EXECUTE | Turns cross track distance bargraph OFF |
| ZOOM IN | Enlarges the graphics display, centers ownship on display |
| ZOOM OUT | Decreases graphics display if previously enlarged with ZOOM IN |
| PAN, < > ∧ ∨, EXECUTE | Moves graphics display area if ZOOM IN is active |
| START NAV, EXECUTE | Starts navigation mode |
| STAT, EXECUTE | Displays status information |
| STAT, LL NNNN, EXECUTE | Changes value of selected status function, where LL is line number and NNNN is numerical data to be entered |
| CLEAR, STAT, EXECUTE | Exit status mode, turns OFF status information |

NOTE: To abort an incomplete command sequence press CLEAR before pressing EXECUTE

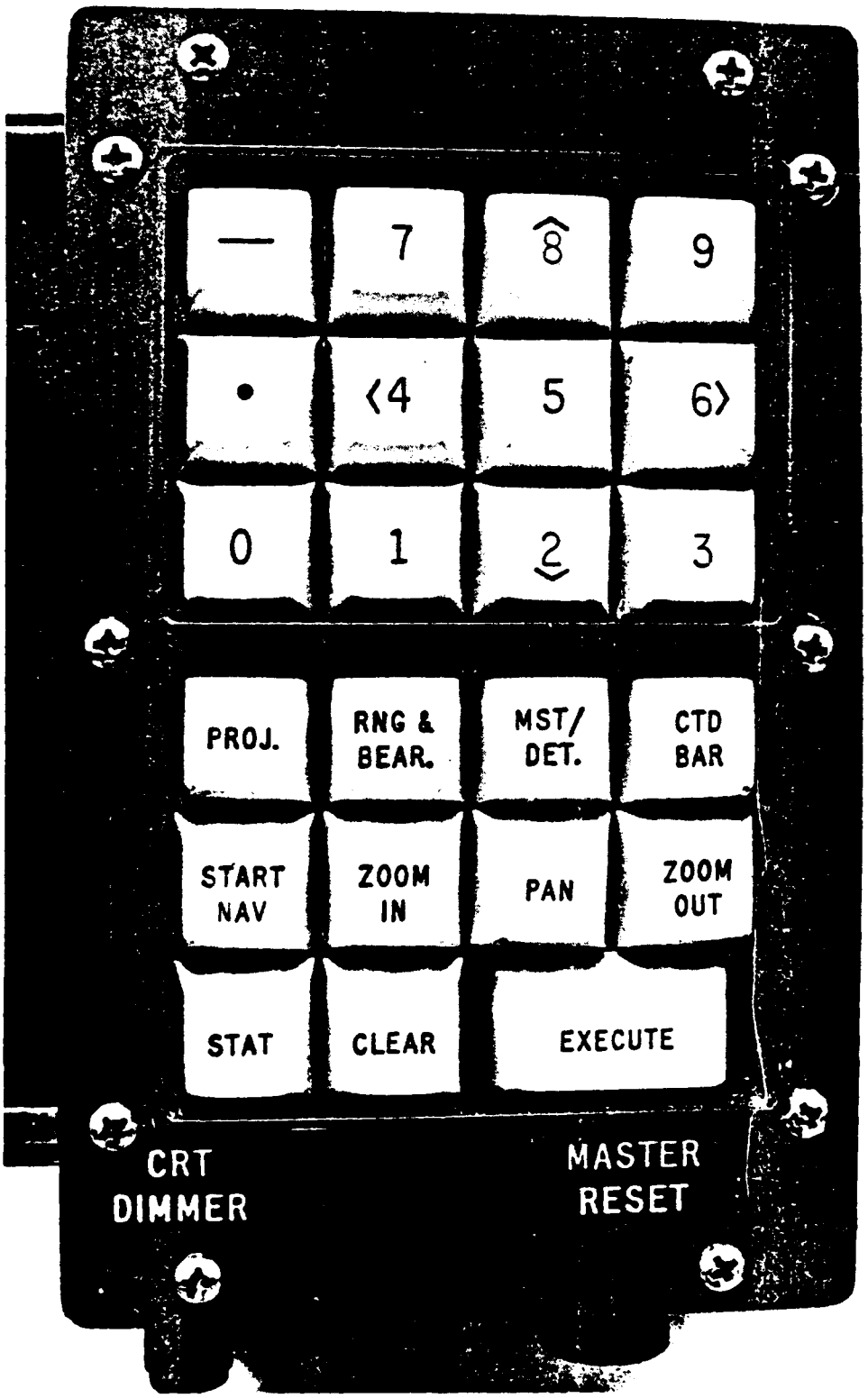



Fig. 7 PILOT keyboard.

```
10 TIME(HH.MM)   13.15
20 WP FILE NO.       3
31 TDA BIAS(ns)      0
32 TDB BIAS(ns)      0
33 TDC BIAS(ns)      0
40 PROJ (CMG=1)      1
     (CMG&RATE=2)
        (GYRO=3)
50 FILTER(F=1,S=3)   2
60 PRINT (Y=1,N=0)   0
70 TEST  (0,1,2)     0
CHAIN  STN       TD
 5930    X    11259570
 5930    Y    22369357
 5930    Z    33161094
HEADING              0.0
GDOP XYZ   0.17
      XY   1.80
      XZ   0.32
      YZ   0.46
```

**Fig. 8 Status display format.**

# 4.0 OPERATING PROCEDURE

## 4.1 GENERAL

The loran receiver must be locked on the proper chain and the correct chart cartridge inserted before commanding the PILOT terminal to start navigating. A warm-up period of 15 to 30 minutes for the loran receiver and the PILOT terminal is necessary before precision use.

## 4.2 TURN ON

Turn the power switches on the loran receiver and the PILOT terminal ON.

## 4.3 SELECT CHART TAPE CARTRIDGE

Select the appropriate chart cartridge for the desired route and chart rotation.

## 4.4 LOCKUP LORAN RECEIVER

Lockup the loran receiver on the loran chain (GRI) and secondary stations specified by the selected chart tape cartridge. Consult the receiver user manual if necessary.

## 4.5 INSERT CHART TAPE AND RESET

Insert the selected chart cartridge into the LEFT tape slot and press the MASTER RESET button TWICE within 0.5 seconds.

## 4.6 OPTIONAL OPERATIONS

If the vessel has already passed beyond the first WP on the chart tape consult the index for the file number of the next expected WP. Enter the file number on STATUS line 20.

Note: The new file number will not be displayed on line 20 at this time.

If the USCG has provided TD Bias values to be used at this time they may be entered on STATUS lines 31, 32, and 33 for TDA, TDB, and TDC respectively. The units for TD Bias are in nanoseconds.

The response time of the digital filtering in the PILOT terminal can be made faster or slower by entering a 1 or 3 respectively on line 50. The default filter value of 2 is best for normal operating conditions.

If a printer is connected to the PILOT terminal, it may be enabled or disabled by entering a 1 or a 0 respectively on line 60. When the printer is enabled, the PILOT terminal will print a one line positive summary every 28 seconds.

Other optional operations include setting the time of day clock on STATUS line 10 hh.mm (this is a 24 hour clock). Also adjust the display brightness if desired.

## 4.7 START NAVIGATION

Verify the loran receiver has settled on the correct TD's and all warning lights are extinguished, then press the START NAV and EXECUTE keys.

## 4.8 CHECK INITIAL POSITION

After the PILOT display has stabilized check the displayed charts (Master and Detail) to verify that they are appropriate. Check the vessel symbol location and heading (Detail only) as well as Along-Track Distance (ATD) and Crosstrack Distance (CTD) against other navigation aids. If they do not agree, recheck your position and recheck the PILOT operating procedure starting at Section 4.3.

Note: Several minutes of PILOT operation are required for ATS, CTS, and TTG to stabilize.

## 4.9 OPTIONAL DISPLAYS

Various PILOT features that may be enabled at this time to enhance the display include:

STATUS. Pressing the STAT and EXECUTE keys will display supplemental information on the right side of the screen. See Section 3.2 STATUS COMMAND and Fig. 8, STATUS

DISPLAY FORMAT for details. To remove the status display from the screen press CLEAR, STAT, and EXECUTE.

CTD BAR. Pressing the CTD BAR and EXECUTE keys will display a crosstrack bargraph along the bottom of the screen. The center of the channel is in the center of the graph with yards left and right of center marked on the graph. The graph will autorange between the 100-0-100 yard and the 500-0-500 yard scale. The length of the moving bar is automatically scaled to the beam of ownship. When the 100-0-100 yard scale is being displayed the number in the center of the moving bar is a repeat of the CTS of the vessel. To remove the CTD BAR from the display press CLEAR, CTD BAR and EXECUTE.

PROJECT. A projection of vessel track for a specified length of time can be displayed by pressing PROJ, mm.m and EXECUTE, where mm.m is project time in minutes. Three different types of project may be selected by the operator by inserting a 1, 2, or 3 on STATUS line 40. A type 1 project is course made good and speed (CMG=1), type 2 project is course made good, gyro turning rate and speed (CMG&RATE=2), and type 3 project is gyro heading and speed (GYRO=3). Project may be removed from the display by pressing CLEAR, PROJ and EXECUTE, or by entering a projection time of zero.

RANGE AND BEARING. The PILOT terminal can continuously compute range and bearing from ownship to any point on the display selected by the operator. Press RNG & BEAR and observe the blinking cursor on ownship. The four cursor steering keys (2, 4, 6, and 8) have now been activated and may be used to position the cursor on top of the desired point. Pressing a cursor steering key once moves the cursor a small distance and holding the key down causes the cursor to accelerate in the direction of the arrow. After the cursor has been positioned, press EXECUTE and observe that the blinking cursor has been replaced with an "*" symbol. The range (yards) and bearing (degrees true) are now displayed on the left side of the screen just below the TTG readout. To remove range and bearing from the display press CLEAR, RNG & BEAR and EXECUTE.

Note: The range and bearing selection is automatically canceled when the currently displayed chart is changed.

ZOOM and PAN. The displayed chart (Master or Detail) may be enlarged by pressing the ZOOM IN key. Each time the key is pressed enlarges the displayed chart and holding the key down causes a continuous zoom action up to a maximum magnification of 16X. Pressing ZOOM OUT has a similar operation except that it reduces the magnification. Each key operates immediately and does not require the EXECUTE key. A "beep" is sounded when either key is pressed after it has reached the limit of its range. The enlarged area of the chart is always shifted so that ownship always approaches the center of the screen, thus if ZOOM IN is used when the ship is underway the ship symbol will remain in the center of the screen and the chart will move.

Note: The zoom selection will automatically be canceled when the currently displayed chart is changed.

Use the PAN key to view an area of the current enlarged chart that is off the edge of the screen. After selecting the degree of magnification desired with the zoom keys, press the PAN key and observe the blinking cursor. Use the four cursor steering keys (2, 4, 6, and 8) to pan to the desired viewing area. Press the EXECUTE key to return the viewing area to ownship.

4.10 TURN OFF. Before turning the PILOT system off, press MASTER RESET twice within 0.5 seconds. After the tape has finished rewinding turn the PILOT terminal power switch OFF.

Note: If the PILOT system is to be used within the next 24 hours and if ship's power is not likely to be switched then it is recommended that the power to the PILOT system be left on with the screen display turned down.

# APPENDIX

## Product Description of

## Internav LC 404 Receiver

Revised
May 21, 1980

# MODEL LC 404
# Loran-C Navigation
# And Monitor Receiver

## PRODUCT DESCRIPTION

## I. Features

- Low instrumental error (less than 40 nanoseconds)
- Low power consumption (15 watts in monitor mode)
- Two way communications
  a. Outputs TDs on command
  b. Outputs status information on command
  c. Reinitiates search on command
  d. Tracking cycle can be changed on command
- High resolution tracking loops
- Measures signal to noise ratio
- Blink indication
- Master independent
- Visual readout of TDs or SNR
- Local or remote control of receiver
- Non Volatile RAM for GRI and secondary memory

## II. General Description

The LC 404 is designed to be a highly accurate Loran-C receiver for precision navigation or monitoring. It will operate as a standard navigation receiver and it contains a two way communication ability which will recognize a message sent to it from a polling unit and respond by sending back time differences and/or other data and execute certain other commands.

Control of the LC 404 can be either LOCAL (front panel) or REMOTE. In either mode, the LC 404 will transmit data in response to remote polling commands.

manufactured by

A. Local Mode - In this mode of operation, the LC 404 is controlled from the front panel and can be used as a normal navigation receiver. The GRI, the secondaries in use, and the cycle sampling points are controlled from the front panel. Simultaneously, the unit can be remotely polled and will reply upon command with time differences and other Loran-C data.

GRI - Determined by Front Panel keyboard - or RAM memory.

TDs displayed - Controlled by front panel or RAM memory.

Data to Remote Accessories - Controlled by keyboard.

Cycle Select Enable/Disable - Controlled by front panel.

Up or Down Cycle Commands - From front panel.

SNR - Can be displayed on front panel through use of front panel controls.

Communications - Responds to external requests for time difference or status information.

B. Remote Mode - In this mode, certain receiver functions can be controlled remotely through the communciations channel.

GRI - Determined by RAM memory.

Secondaries Tracked - Determined by RAM memory.

TDs displayed - Selected by front panel keyboard.

Data to remote accessories - Selected by front panel keyboard.

Cycle Select Enable/Disable - Remotely controlled.

UP or DOWN Cycle Commands - Remotely controlled.

SNR - Can be displayed on front panel using front panel switches.

Communications - Same as Local Modes

Search Initiation - Remotely Controlled

Low Power Operation - When in the REMOTE mode the LC 404 front panel may be disconnected completely thus conserving power usage.

III. Communications Function

The LC 404 will recognize polling requests which are sent to it and will respond with the requested time difference or status information. Each unit is assigned an ID number from 0 to 255 (set via the internal DIP switches). The polling unit sends out a polling message which contains the ID of the unit it wishes to respond, the type of information requested, and, in the REMOTE mode, whatever commands it wishes the receiver to execute.

If time differences are requested, the receiver responds with up to four TD's and an alert bit for each signal being tracked. If status information is requested, the receiver sends back a status byte for each signal and a measure of oscillator offset.

Details of the POLLING and REPLY messages are given in Sections V and VI.

IV. Detailed Specifications

A. Absolute Accuracy

The error due to any of the following individual range of signal conditions will be less than 25 nanoseconds.

a. Absolute signal level 25 to 105 DB/uv/meter.
b. Differential signal levels 0 to 60 DB.
c. Differential ECD - plus or minus 4 $\mu$sec.
d. Signal-to-noise -10 DB atmospheric or greater.
e. Crossing rate interference S/CRI greater than -20 DB.
f. CW interference S/CWI greater than -20 DB (when notched.

B. Noise

The standard deviation of the time differences will be less than 20 nanoseconds at a signal-to-atmospheric noise ratio of 0 DB.

C. Tracking

Receiver will maintain track over the following range of signal conditions.

a. Signal-to-noise greater than -23 DB atmospheric or better.

b. CW interference S/CWI greater than -40 DB (when notched).

c. Envelope to cycle difference plus or minus 4 $\mu$sec.

d. Absolute signal level 10 to 114 DB/luv/meter.

D. Acquisition and Settling

Receiver will acquire and settle to the correct cycle over the following range of signal conditions.

a. Signal-to-noise greater than -15 DB atmospheric.

b. CW interference S/CWI greater than -32 DB (when notched).

c. Envelope to cycle difference plus or minus 3.5 $\mu$sec.

d. Absolute signal level 25 to 105 DB/luv/meter.

E. Temperature Range - 0 to 55 degrees C.

F. Size - 5.7" high x 12.6" wide x 13.2" deep.

G. Weight - 20 lbs.

H. Resolution of tracking loop steps 10 nanoseconds.

I. Tracks Master and up to four secondaries.

J. Supply Voltage - 10 to 15 volts DC, 15 watts (with front panel display off).

K. TD Resolution - 1.0 nanosecond - transmitted data
.01 microsecond - front panel readout

L. Data output device - USART INTEL 8251A.

M. Baud rate - 1200 asynchronous.

N. Two internal notch filters can be set by a technician. (Not operator tuneable.)

O. The LC 404 is Master independent in that if Master Lost Signal is detected for a period of 100 GRI's, oscillator compensation is switched to the first secondary that was acquired. Thus time differences between secondaries remain valid.

P. Time differences output remotely are sampled simultaneously.

Q. The LC 404 contains Modulator and Demodulator IC's for receiving or sending tones.

V. Format of Polling Message

Byte 1 - Receiver ID - 0 to 255 LSB first.

Byte 2 - First Digit - Type of reply requested.

Bit 0 = 1 - Send back TD's

Bit 1 = 1 - Send back Status Message

Bit 2 = 1 - Send back all 8's (Except ID)

Second Digit - Type of command - Binary encoded.

0 = Do nothing

1 = Up one cycle

2 = Down one cycle

3 = Drop signal

4 = Search for Signal

5 = Cycle Select Enable - Track Sample 50%

6 = Cycle Status Enable - Track Sample 75%

7 - Cycle Sample Disable - Track Sample 100%

Byte 3 First Digit - Execute Command on Signal X.

0 = Master

1-8 = MSD of Signal TD

9 = All

Second Digit - Spare

VI. Format of Reply Message

A. TD Reply

Byte 1 - Receiver ID 0 - 255 LSB first

Byte 2 - TDA 1 nanosecond digit LSB first
TDA 10 nanosecond digit

Byte 3 - TDA 100 ns digit
TDA 1 µsec digit

Byte 4 - TDA 10 µsec digit
TDA 100 µsec digit

Byte 5 - TDA 1 MS digit
TDA 10 MS digit

Byte 6-9 TDB 1 nsec digit first

Byte 10-13 TDC (if active) Else Zeros

Byte 14-17 TDD (if active) Else Zeros

Byte 18 - Signal Alert

Bit 0 = 0 if M - Status OK

Bit 1 = 0 if S1 - Status OK or Not Active

Bit 2 = 0 if S2 - Status OK or Not Active

Bit 3 = 0 if S3 - Status OK or Not Active

Bit 4 = 0 if S4 - Status OK or Not Active

Bit 5 = 0 if command executed

B. Status Reply

Byte 1 - Unit ID

Byte 2 - Master Status

Bit 0 = 0 if $\overline{LS}$

Bit 1 = 0 if $\overline{BLK}$

Bit 2 = 0 if STLD Once and Cycle jumps disabled

Bit 3 = 0 if Cycle Status Disabled

Bit 4 = 0 if $\overline{\text{tracking too low}}$

Bit 5 = 0 if $\overline{\text{tracking too high}}$

Bit 6 = 0 if $\overline{\text{Search}}$

Bit 7 = 0 if $\overline{\text{warn}}$

Byte 3 - S1 Status

Byte 4 - S2 Status

Byte 5 - S3 Status

Byte 6 - S4 Status

Byte 7 - Master SNR - SNR in db. LSD first. If first digit is 5 or greater the number is negative. Subtract 5 and append minus sign. 08 equals + 8db. 58 equals -8db. SNR is measured by determining the percent of time the noise amplitude exceeds signal amplitude. Thus it is most sensitive to atmospheric impulses and crossing rates. SNR tends to become insensitive to SNR's greater than +10db.

Byte 8 - S1 SNR

Byte 9 - S2 SNR

Byte 10 - S3 SNR

Byte 11 - S4 SNR

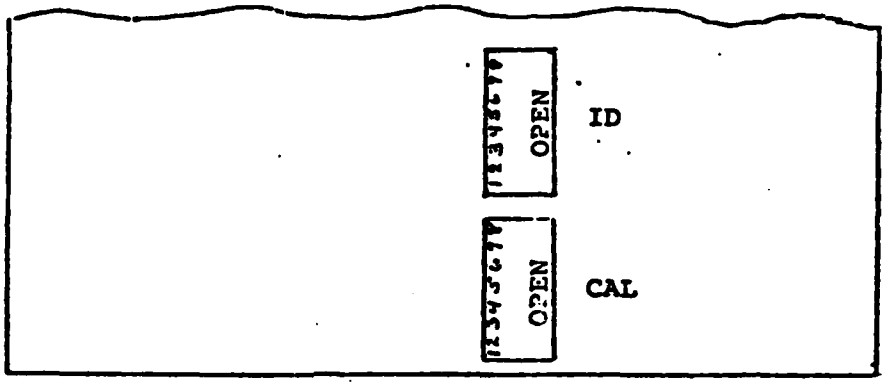
Byte 12-15 GRI (Oscillator Offset) LSB first - LSD = 1 n sec.

Byte 16&17 - zeros

Byte 18 - Prog. Rev. No.

## VII. DIP Switches

DIP Switches are arranged on PC Card as shown:




DIP Switch 1 -

Receiver ID Number - 0 to 255 binary encoded.

Position 1 = 1 bit

Position 8 = 128 bit

DIP Switch 2 -

Receiver Calibration Factor - Nanoseconds

Position 8 - IF 0 Cal Factor Positive
IF 1 Cal Factor Negative

Position 5-7 - Binary Encoded Value of 1st digit. Range is 0 to 7.

Position 1-4 - BCD Encoded Value of 2nd digit. Range is 0 to 9.

Total range is thus -79 to +79 nanoseconds.

internav

CAUTION!!!

Due to a shortage of our standard antenna coupler cable, we are forced to use a substitute cable. The only difference is the substitute does not have color coded signal leads. This will pose no problem unless the cable is cut during installation. Both ends of the substitute cable are labeled for identification purposes should it be necessary to disconnect the connector or antenna coupler during installation. Should the cable have to be cut during installation, follow this procedure:

1. Figure 5-6 of the LC112 installation manual and Figure 6-6 of the LC123 operation/installation manual show the correct wiring diagrams for the antenna coupler cable.

2. With both ends of the cable disconnected from the receiver and antenna coupler, use an ohmmeter to check for continuity.

3. Mark both ends of one signal lead blue.

4. Mark both ends of the other signal lead white.

5. Connect the leads to the antenna coupler and connector per the applicable figure mentioned in item 1 above.

Failure to connect the signal leads properly will result in the Loran-C receiver tracking the wrong part of the Loran-C pulse, resulting in an incorrect time-difference readout.

Internav

DATE: 6/26 1980

Information Bulletin NO. 027

SUBJECT: Replacement of 10 pin Data Output Connector J-4 on the rear panel of Simrad/Internav LC123 Loran C receivers with a 15 pin connector.

APPROVED

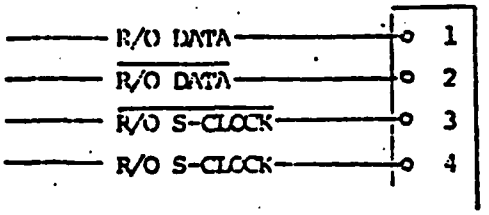
This Dealer Bulletin affects Simrad/Internav LC 123 Loran C receivers shipped on or after June 9, 1980

Beginning with serial number 60210, Simrad/Internav LC 123 receivers will be manufactured with the following change.

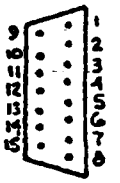
---

The 10 pin Data Output Connector , J-4 (Part# Bendix PT02E-12-10SN) on the rear panel of the LC 123 will be replaced with a 15 pin (Part# TRW DA-15S) connector.

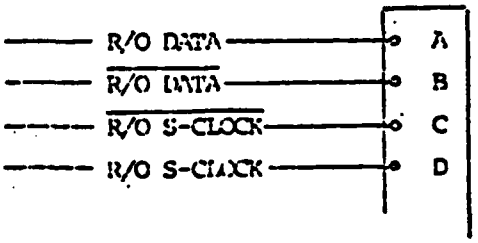
The wiring connections to the 15 pin connector are as follows:



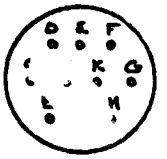

Rear view of the 15 pin connector




For your information, the 10 pin bayonett lock connector was connected as follows:




Rear view of the 10 pin connector




When ordering accessories to be operated from this Data Output Connector such as a CT-2 Internavigator or IL Remote Readout, be sure to indicate the type of mating connector to be supplied with the accessory.

SUBJECT: Attaching the 15 pin Data Output Connector to SIMRAD/ INTERWAY accessory interconnecting cables.

APPROVED___

Unsolder the existing 10 pin connector from the interconnecting cable and lable the ends of the unsoldered leads as in fig. 1.

Slide the connector shell onto the interconnecting cable as in ficure 1.

Solder the labled ends of the wires into the connector housing as follows:

| | |
|---|---|
| 'A' to pin 1 | 'C' to pin 3 |
| 'B' to pin 2 | 'D' to pin 4 |

Align the 'slide locking clip' with the small end up (see f g. 2) and pass the brass plated screws through the clip, through the connector housing and through the connector shell. Secure with the elastic stop nut OR the lock washer and regular nut provided.

Tighten the strain relief clamp on the connector shell.

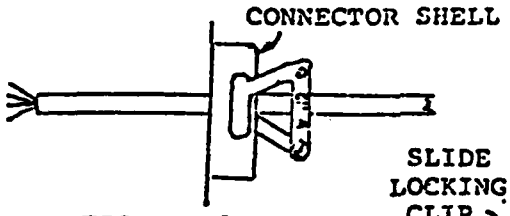



FIGURE 1.

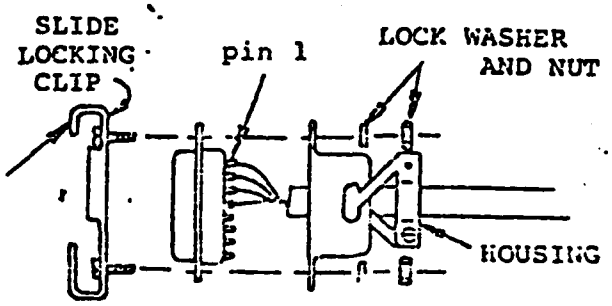



FIGURE 2

Connect the assembled connector to the Data Output Connector of a SIMRAD/INTERWAY or C receiver:

Move the slide locking clip UP to connect.

Carefully plug the connector into the proper output connector on the rear of the Simrad C receiver.

Move the slide locking clip DOWN to lock the connectors together.

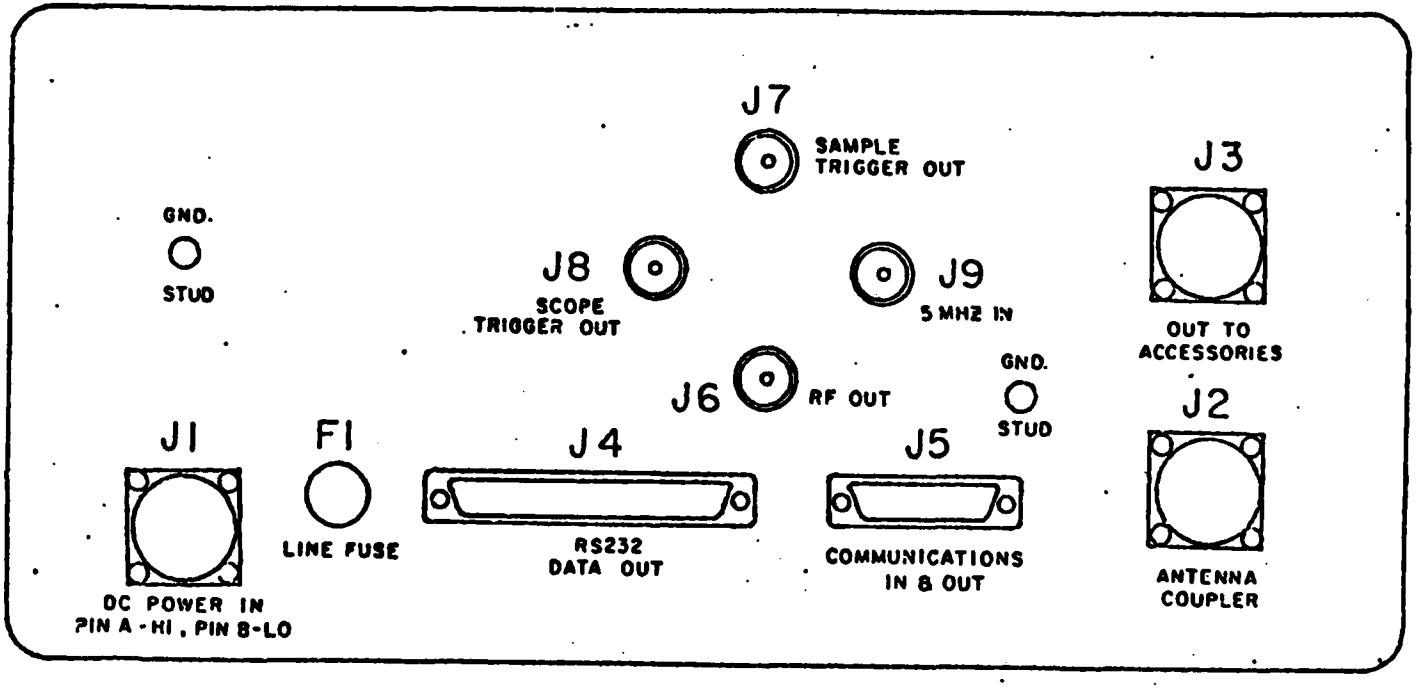
## LC 404 OPERATION SUMMARY

| Operation | Operator Action | Results |
|---|---|---|
| 1. Turn Receiver ON | ON/OFF switch to ON | |
| 2. Select a Loran-C Chain GRI* | M,9,9,6,0,E | Display echos entries |
| 3. Select the first two secondary stations* | 1,4,E (Digit is the most significant digit of desired secondary TD) | Initially all "0"s displayed. Then display alternates between GRI and all "8"s. Then when Master is found, display blanks. |
| Wait until TDs of the first two secondaries are displayed before proceeding | | |
| 4. Select a 3rd and/or 4th secondary* | +,2,E | Receiver will acquire #2 secondary. No observable display change |
| | +,6,E | Receiver will acquire #6 secondary. No observable display change. |
| 5. To display any pair of TDs | 4,6,E or 1,6,E | TDs 4 & 6 will be displayed or, 1 & 6. |

*These steps must be performed the first time you turn on the LC404, or if you wish to use a different Loran-C chain. Normally, the LC 404 will perform operations 2, 3, and 4 automatically when power is applied.

| Operation | Operator Action | Results |
|---|---|---|
| 6. Lock the Keyboard | +,+,E | Only Keyboard entry recognized is Unlock. |
| 7. Unlock the Keyboard | -,-,E | All valid entries recognized |
| 8. Display GRI of Loran-C chain (as measured by internal oscillator) | M,D,E | GRI will be displayed (U) "D" Secondary displayed (L) "D" is any digit 1-9. |
| 9. Save a pair of displayed TDs in memory. (Up to five pairs may be stored). | E | Display at time of entry is stored. |
| 10. Recall a pair of TDs | D,E | Recalls "D" pair of TDs. Pairs are numbered on last in first out basis. |
| 11. Erase all stored TD pairs | A,C | Storage memory is erased. |
| 12. Display SNR of "D" station | D,M,E | "D" TD is displayed (U) SNR is db displayed (L) |

| Operation | Operator Action | Results |
|---|---|---|
| NOTE: The following Keyboard sequences are only recognized if the internal LOCAL/REMOTE Switch is in Local. | | |
| 13. Enable Cycle Jumps | +,E | RF Samples are shared 50/50 between track and cycle select. Cycle jumps are enabled. |
| 14. Enable Cycle Status | A,E | RF Samples are shared 75% for track, 25% for cycle select. No cycle jumps can occur. Status digit will indicate an incorrect cycle. |
| 15. Disable Cycle Sampled | -,E | RF Samples are all used for track. No cycle jumps allow. Status digits will not display incorrect cycle. |
| 16. Move Station Tracking Point Up or Down | +,M,E | Master tracks one cycle higher. |
| | -,M,E | Master tracks one cycle lower. |
| | +,A,E | All Stations track one cycle higher. |
| | -,A,E | All Stations track one cycle lower. |
| | +,D,E | "D" Secondary tracks one cycle higher |
| | -,D,E | "D" Secondary tracks one cycle lower. |
| 17. Drop a station which is in search or track | D,-,-,E | "D" Secondary will be dropped. |




# LC-404 Connectors

## REAR VIEW

LC 404

## Communications Interface

Remote communication with the LC 404 can be either with digital (TTL level) signals or with frequency shift keying, FSK. Message formats, word formats, and bit rates are the same for both cases.

Word Format - 1 start bit, 8 data bits, 1 stop bit

Baud Rate - 1200 bps

Message Format - See product description

Logic Sense - 1=High (5 volts) 0=Low (0 volts)

Signal Definitions:

J5-2 DPM - Digital Polling Message - This is the incoming digital message to the LC 404 from the polling unit.

J5-10 FSKPM - FSK Polling Message - Same as DPM but FSK.

J5-3 $\overline{\text{DPRQ}}$ - Digital polling request - This line is normally high and should go low at least 1 ms before DPM commences.

J5-7 $\overline{\text{LKDET}}$ - Lock Detect - Same as $\overline{\text{DPRQ}}$ but for FSK poll.

J5-1 FSKP - FSK Poll - This line should be high in FSK mode, low in digital mode.

J5-4 DRM - Digital Reply Message

J5-9 FSKRM - FSK Reply Message

J5-8 $\overline{\text{TXON}}$ - Used to activate XMTR when used. This line goes low 20 milliseconds before reply message is sent.

## LC 404 STATUS DIGIT

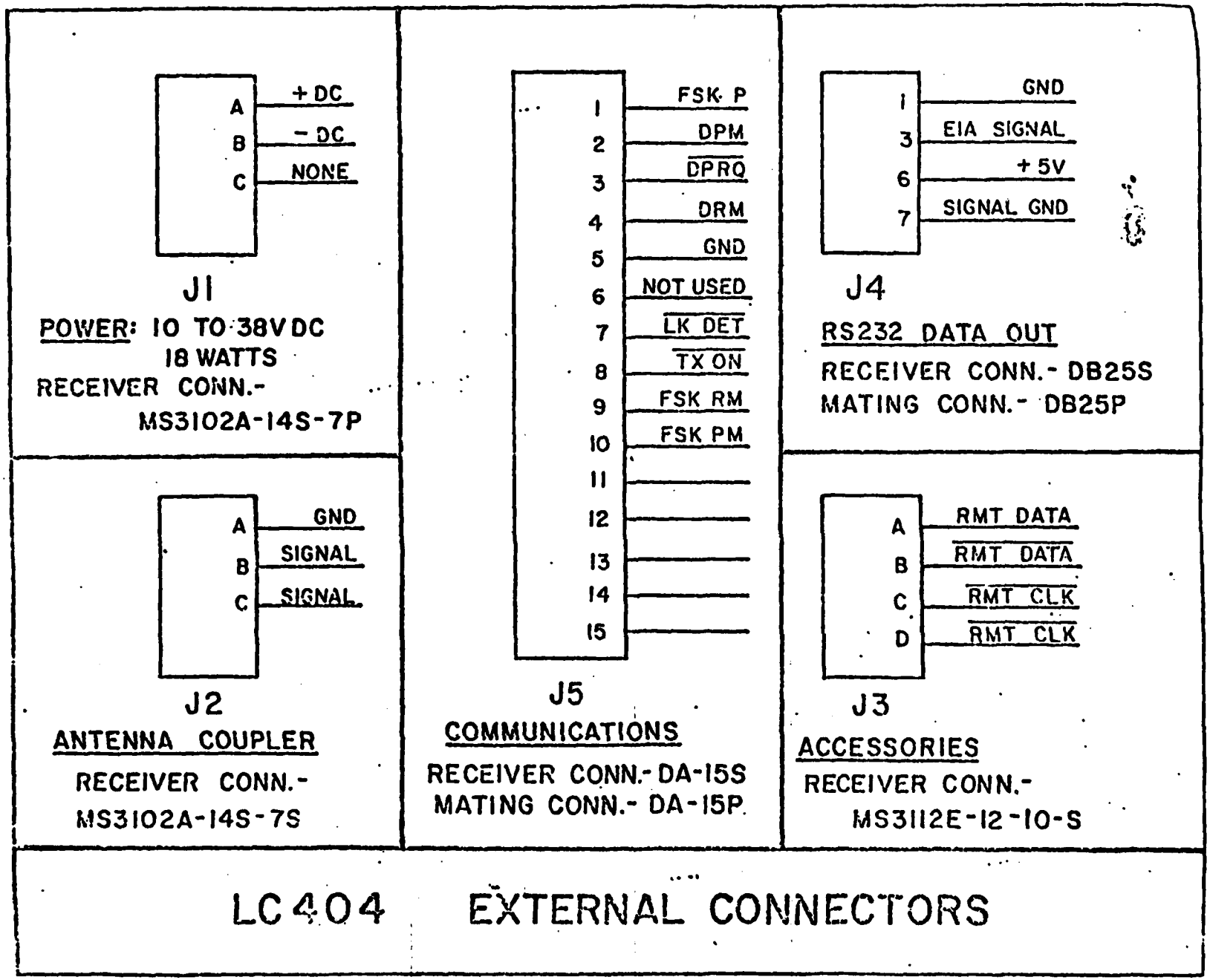
The eighth digits on the upper and lower displays are encoded to indicate the status of the displayed station.

Blank - Everything OK.
0 - Lost Signal
1 - Station is blinking
2 - Station has not settled*
3 - Cycle Jumps Enabled
4 - Cycle Status Enabled
5 - Tracking too low on pulse (Cycle Status must be enabled)
6 - Tracking too high on pulse
7 - Warning**
8 - Search

*Upon initial acquisition, a station is not considered "Settled" until 2000 GRI's have elapsed since the last cycle correction.

**The Warning status will latch if lost signal occurs lasting for more than 100 GRI's. This warns the operator that an extended lost signal did occur and cycle slippage was possible.

NOTE: If master status is other than "blank" the rightmost upper and lower decimal points will blink. Master status may be observed by pressing M,D,E.


A
B
C
+ DC
- DC
NONE
J1
POWER: 10 TO 38V DC
18 WATTS
RECEIVER CONN.-
MS3102A-14S-7P
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
FSK P
DPM
DPRQ
DRM
GND
NOT USED
LK DET
TX ON
FSK RM
FSK PM
J5
COMMUNICATIONS
RECEIVER CONN.- DA-15S
MATING CONN.- DA-15P
1
3
6
7
GND
EIA SIGNAL
+ 5V
SIGNAL GND
J4
RS232 DATA OUT
RECEIVER CONN.- DB25S
MATING CONN.- DB25P
A
B
C
GND
SIGNAL
SIGNAL
J2
ANTENNA COUPLER
RECEIVER CONN.-
MS3102A-14S-7S
A
B
C
D
RMT DATA
RMT DATA
RMT CLK
RMT CLK
J3
ACCESSORIES
RECEIVER CONN.-
MS3112E-12-10-S
LC404 EXTERNAL CONNECTORS